No. 815

AIR LEAKAGE THROUGH A PIVOTED METAL WINDOW

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MEMBERS

DURING the fall of 1927 an opportunity presented itself for the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS to make a study of air leakage through a pivoted window in the Grand Central Palace Bldg., Lexington Ave. and 46th St., New York City, during the Power Show. The set-up and the operation of the test served as an exhibit and demonstration of the work of the Laboratory.

Description of Building

The Grand Central Palace, Fig. 1, is a 12-story building, facing Lexington Ave. from 46th St. to 47th St., and is 270 ft. deep. The study was made in a window facing west, about 25 ft. from the north corner of the 4th floor. The nearest obstruction to free wind movement west of this window was at a distance of approximately 52 ft. 6 in., so that the wind had a fairly clear sweep from the northwest through 47th St., and this vacant space.

The first four floors of the building were used as exhibition space in the Power Show and were interconnected by large open stairways. None of the floors were subdivided into rooms. There was little tendency, therefore, for the air leaking in through the windward windows to build up pressure within the room—for the reason that it could easily get out of the building around the large number of windows and doors on the opposite side.

The window studied, Fig. 2, was of the hollow metal vertically pivoted type. Each window unit was divided into four sections by the metal frame which was flush with the plastered wall. The perimeter tested was 20 ft. 4 in. The joint between the plaster and the frame was tight and appeared to offer little opportunity for frame leakage. The window sash was not in good shape and fitted very loosely into the frame without weatherstripping.

Test Procedure

The apparatus used and the method of conducting tests was identical with that

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used in the Southwestern Bell Telephone Bldg., and described in an earlier Laboratory report.[3] The collecting hood, the meter for measuring the leakage, the control valves and the exhaust blower were connected to the window as shown in Fig. 3. This method of application differs from that used in the investigation just referred to only in that tie-rods were used for drawing the hood up to the wall around the window instead of the brace and jack-screw used in the earlier study.

FIG. 1. GRAND CENTRAL PALACE BUILDING, LEXINGTON AVE. AT 46TH ST., NEW YORK, N. Y.

Fig. 4 is a photograph of the test set-up. The window is hidden from view by posters and signs.

The test manipulation was the same as that referred to in the earlier report and will not be repeated here. Tests were made with both natural and artificial wind pressures. When the leakage resulting from natural wind pressures was measured, the air leaking through the window into the hood and the pressure drop through the window were measured simultaneously for the wind prevailing at that time. The leakage for artificial wind pressures was measured by artificially producing a pressure drop through the window by exhausting air from the hood.

[3] Air Leakage Studies on Metal Windows in a Modern Office Building, by F. C. Houghten and M. E. O'Connell, TRANSACTIONS, 1928, OF AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, p. 321.

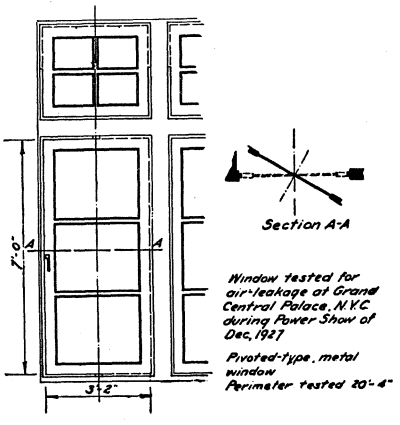

FIG. 2. PIVOTED METAL WINDOW

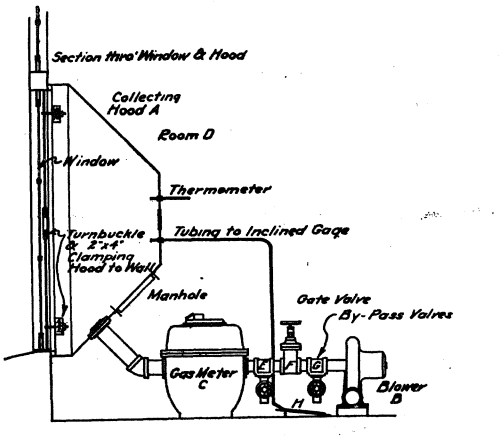

FIG. 3. APPLICATION OF AIR LEAKAGE APPARATUS TO WINDOW

Test Results

The leakage for the natural wind pressures is given by the points x in Fig. 5, in which the leakage through the window in cubic feet per minute is plotted against the pressure drops through the window and the accompanying velocity. It will be noted that the highest wind velocity experienced was a little more than 10 mi. per hour. The test points for artificial wind pressures are plotted as circles.

As was found in the study in the Southwestern Bell Telephone Bldg., the test

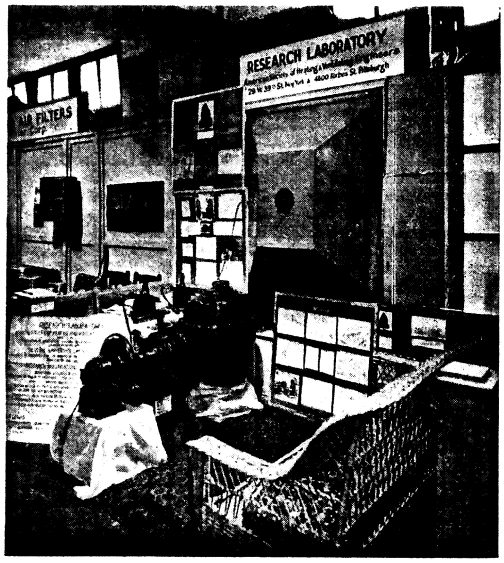

FIG. 4. TEST SET-UP AND EXHIBIT AT THE POWER SHOW, DECEMBER 5–10, 1927

points for natural and artificial wind pressures fall very well on the same curve, and it may be assumed that the curve as drawn in Fig. 5 represents the true condition of leakage for any wind velocity.

Table 1 gives the leakage in cubic feet per hour per lineal foot of crack around the window. It should be pointed out that no attempt was made to eliminate leakage between the plaster and frame on the one side and bottom of the window covered by the hood. As previously stated, however, the joint between the plaster

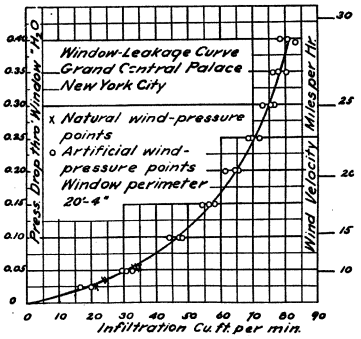

FIG. 5. RELATION OF AIR LEAKAGE TO WIND PRESSURES AND VELOCITY

and the frame appeared to be well sealed, and one would not expect a very large error due to frame leakage. The table also gives leakage for the entire area of the window studied; that heat loss in B.t.u. per hour required to heat the air leaking in from 0 to 70 deg. fahr. and the square feet of radiation required to supply this heat loss.

The last column of the table gives the cost of installing radiation to take care of the heat loss, based upon $2 per sq. ft. installed. This would indicate that the application of weatherstripping and the resultant decrease in the amount of radiation installed would give a considerably lower first cost for the completed building—to say nothing of the saving in heat thereafter.

It is of interest to compare the leakage through this window, which was noticeably loose-fitting, with the leakage through the windows of the Southwestern Bell Telephone Bldg. as given in the report previously referred to. If this comparison is made on the basis of a 20-mile wind velocity, the unweather-stripped window in

TABLE 1. INFILTRATION THROUGH METAL WINDOW TESTED AT N. Y. POWER SHOW, GRAND CENTRAL PALACE, 1927

Wind Velocity, Miles per Hr.	Leakage, Cu. Ft. per Hr. per Ft. of Perimeter	Total Cu. Ft. per Hr.	Heat Loss, B.t.u. per Hr. 0–70° F.	Sq. Ft. Radiation	Cost of Radiation at $2.00 per Sq. Ft. Installed
5	29.5	600	756	3.2	$ 6.40
10	88.5	1800	2268	9.5	19.00
15	144.5	2940	3710	15.5	31.00
20	186.0	3780	4767	19.9	39.80
25	221.5	4500	5677	23.7	47.40
30	242.0	4920	6202	25.9	51.80

the Southwestern Bell Telephone Bldg. leaked 120 cu. ft. per hour per foot of crack without weatherstripping, and 57 cu. ft. per hour per foot of crack with weatherstripping, as compared with 186 cu. ft per hour per foot of crack for the window in the Grand Central Palace Bldg.

DISCUSSION

E. C. EVANS: I would like to ask the author if the window he had under discussion was a poor type of window that fit irregularly or would it be considered as a general type of window of that construction?

W. C. RANDALL: The point I would like to mention about this paper is that apparently one window had been used and, based on the remarks of the last speaker there will be an inclination to use the data even though based on but one window. It is perfectly possible that hollow metal windows are not represented by this chart adequately.

The other point is that the author has transferred the infiltration into square feet of radiation.

Now, the data which he has shown would seem to indicate that he did not get the drop in pressure of greater than the equivalent of about 10 miles wind velocity, whereas the wind was actually blowing more than that, and the building in a more or less exposed position.

It seems to me there has to be a better known relation between the wind velocity at the recording station and the drop in pressure between the outside and inside faces of the window before we can interpret into square feet of radiation.

J. E. EMSWILER: Mr. Houghten has in common with the usual practice on the infiltration test expressed the quantities here as heat loss in B.t.u.'s per hour and has referred to the 70 deg. basis. We, of course, all understand that to be a figure upon which is based the calculation of an extra portion of radiation necessary to take care of that infiltration.

The point I want to make, however, is that this heat loss item may possibly be misinterpreted by some and interpreted to mean an actual loss in B.t.u.'s that is existing at all times.

Now, of course, infiltration is taking place only during a relatively small percentage of the total year or total heating season, and we ought to be particularly careful to make the point that if infiltration is cut in half, for example, it isn't going to mean any extensive heat loss or heat saving, after all.

F. C. HOUGHTEN: Mr. Evans asked concerning the condition of the window on which the data reported was collected. As pointed out in the paper, the window is of the vertical pivoted type and in rather poor condition as regards tightness of fit. I believe one would expect a window in a ten-year old building to be in a rather poor condition, but we are not in a position to say whether or not the window tested is typical of those found in buildings of similar age.

As pointed out by Mr. Randall, the data were collected on only one window and the importance of the findings should be discounted due to this fact. However, they should be of some value in indicating what may be expected under existing conditions in old buildings.

There is always the question of application of a wind velocity reported by the Weather Bureau, to any particular building. The wind as reported by the Weather Bureau is probably a maximum to which some buildings are subjected, while most buildings are subjected to much lower wind velocities. The best that can be done in making a practical application at the present time is to accept the velocities reported by the Weather Bureau.

As pointed out by Professor Emswiler, the highest wind velocities are perhaps never accompanied by the lowest temperatures. This is a question of paramount importance in applying such data as those contained in the paper, to determine heat loss from buildings. Such application is, however, not so much a function of this paper as it is of THE GUIDE Publication Committee who are wrestling with it in developing the chapter of heat losses from buildings. The heat loss values as given in the paper are primarily of value, in comparing relatively, the heat loss by infiltration for different types of windows and building construction. In recommending methods of applying these data in THE GUIDE, it will probably be desirable to take some percentage of the values actually found in the test, as has been done in developing other tables for air leakage from laboratory data.

In the discussion it was brought out that maximum wind velocities are met with over a very small proportion of the heating season and that the extra radiation necessary on a cold windy day to take care of infiltration, will not reflect a relative increase in total heating requirement for the season. This is, of course, quite true, but nevertheless, sufficient radiation must be installed to meet the worst condition, and the first cost of installing such radiation can be eliminated by cutting out the air leakage, In this connection, it should be pointed out that in the case of any window giving an excessive leakage, the first cost of installing a better window or leakage retarding device, is more than off-set by the reduction in cost of radiation.